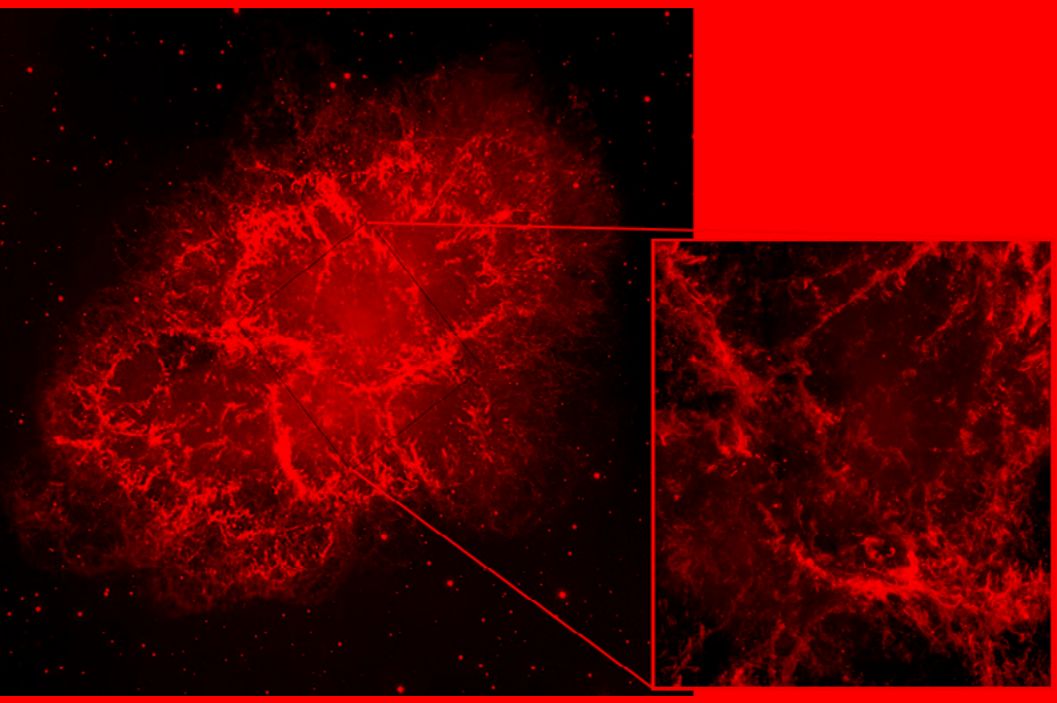
National Aeronautics and
Space Administration

UNIVERSE DISCOVERY GUIDES

December

CRAB NEBULA



The Crab Nebula: The remains of a star that exploded as a supernova about one thousand years ago. Credit: European Southern Observatory (ESO)

In this Hubble close-up of the Crab Nebula, various chemical elements have been detected in the expanding gas, including hydrogen (orange), nitrogen (red), sulfur (pink), and oxygen (green). Some of these elements are newly generated during the life and the explosive death of the star and now blasted back into space. These chemical elements will eventually be incorporated into new stars and planets. Credit: NASA, STScI/AURA
More details: http://hubblesite.org/newscenter/archive/releases/2000/15/image/a/

IN THIS GUIDE

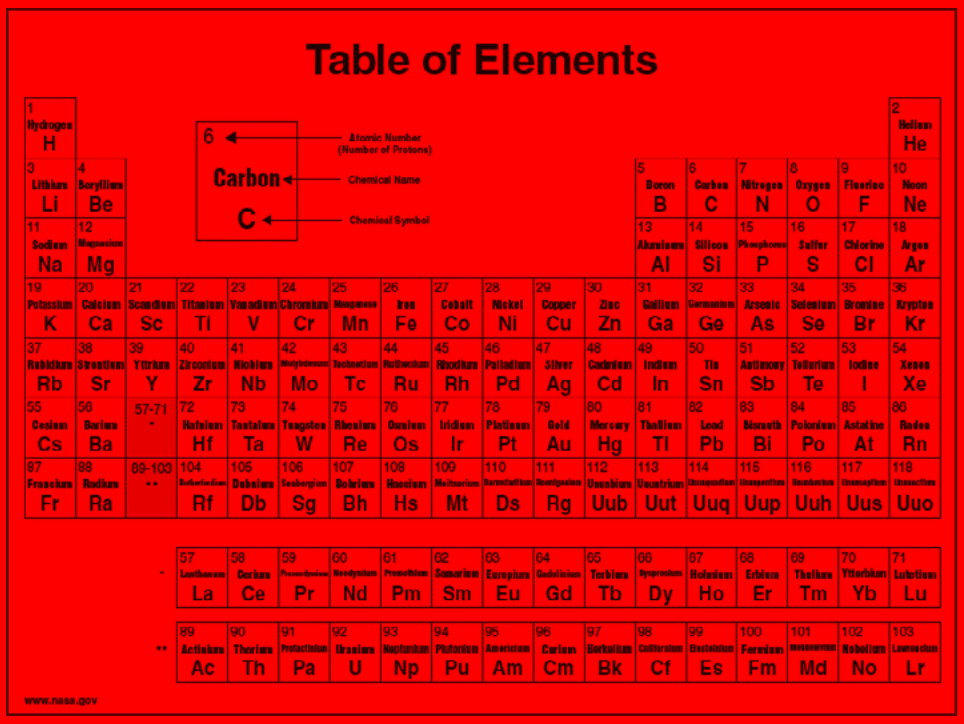
Published 2013.

The universe is a place of change. NASA missions advance our understanding of the changing universe. www.nasa.gov

CHILDREN OF THE STARS

Where did the calcium to build your bones come from? How about the iron in your blood or the oxygen in the air we breathe?

You may have seen the table of the elements — these are the atoms which are the building blocks that make up everything we see, including us. Some of those atoms combine to make molecules, like water (consisting of hydrogen and oxygen) and sugars (consisting of carbon, hydrogen and oxygen) — ingredients for supporting life.



The number of protons in the atom's nucleus determine which element it is. For example, hydrogen has one proton; helium has two protons; carbon has six protons; iron has twenty-six protons.

But how did these elements form?

You are a Child of the Stars

Perhaps you have heard the saying that you are a child of the stars. This is true. Almost all of the elements originally formed inside of stars. The most massive stars are the ones that generate the greatest variety of elements — during their lifetime and during the spectacular supernova explosion that marks the end of the star's life.

The universe is a dynamic place, always changing. The universe has not always had an abundance of elements.

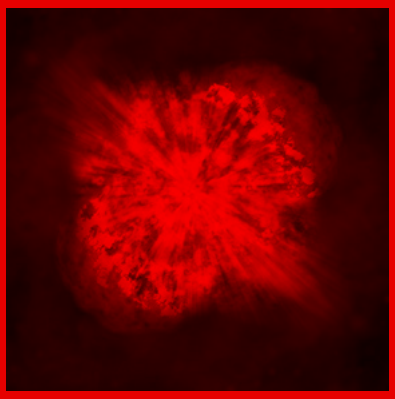
At the beginning of the universe, shortly after the Big Bang, hydrogen and some helium were about all there was. When the stars eventually formed, their hot cores became nuclear furnaces where hydrogen can fuse to make helium, helium can combine to produce carbon, carbon and helium can combine to form oxygen, and so on. Through various combinations and processes, heavier and heavier elements are forged until we get to iron.

The fusion process stops at iron, and at that point, a massive star's core collapses under its own weight. An explosive shock wave and the energy generated from the core collapse starts moving outward, heating the surrounding layers of the star, and BOOM. Most of the star is blasted into space in an enormous supernova explosion.

But wait! What about elements heavier than iron, like the copper we use in plumbing, or zinc, which we combine with copper to make brass? How about the silver we use for jewelry? Well, massive stars can make those, too — during the supernova explosion itself.

During the collapse and explosion, the central temperature of the star goes from over a hundred million degrees to over a hundred BILLION degrees, allowing elements heavier than iron to be generated, all in just a few seconds. The explosion releases all these elements back into space, where they eventually combine with other gas and dust to make new stars, planets, and the ingredients of life.

Look around you. Almost everything you see here on Earth, including you, is here because of massive stars that exploded in the billions of years before our Sun was born. You and the Earth we live on are children of the stars.



Credit: Illustration: NASA/CXC/ M.Weiss

Image credit: Rozum / 123RF Stock Photo

SKY FEATURE: CRAB NEBULA

How to Find it

Distance: 6,500 light-years

Diameter: About 5 light-years across

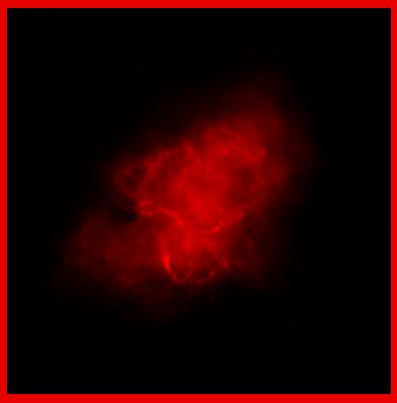
Visual Magnitude: 8.4

To view: Telescope in dark skies

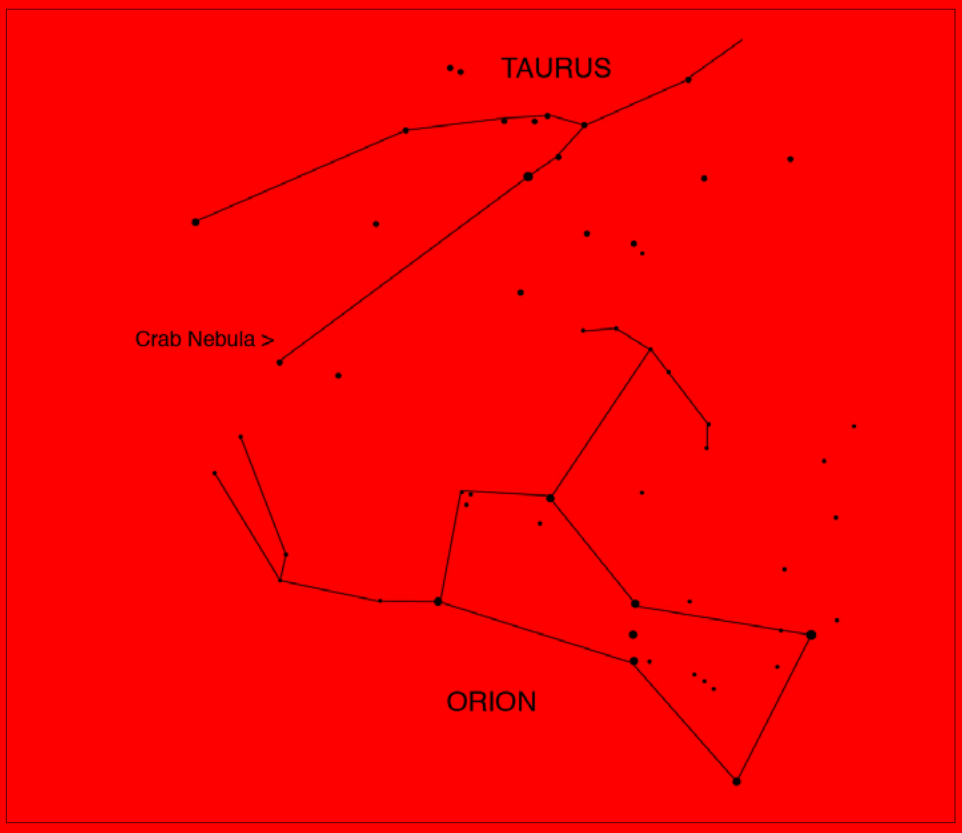
Click here to jump to the full-sky December Star Map.

In December in the late evening, the Crab Nebula is above the eastern horizon, in the constellation of Taurus, the Bull. One of the few supernova remnants visible in backyard telescopes, the Crab Nebula is near the star marking the tip of one of the Bull's horns.

Historical Chinese and Arab records from 1054 A.D. described a bright "guest" star that could even be seen in the daytime. Besides the Sun and Moon, it was easily the brightest object in the sky for several months. Then it faded from view. It turned out they saw the supernova explosion that originally created the Crab Nebula. In the 1700s, astronomers using telescopes saw it again, but this time only as a faint cloud.



Crab Nebula. Image credit: NASA/ JPL-Caltech/R. Gehrz; Spitzer Space Telescope



The Crab Nebula got its name in 1840 when the astronomer William Parsons created a drawing of the nebula that he thought looked like a crab and the name stuck.

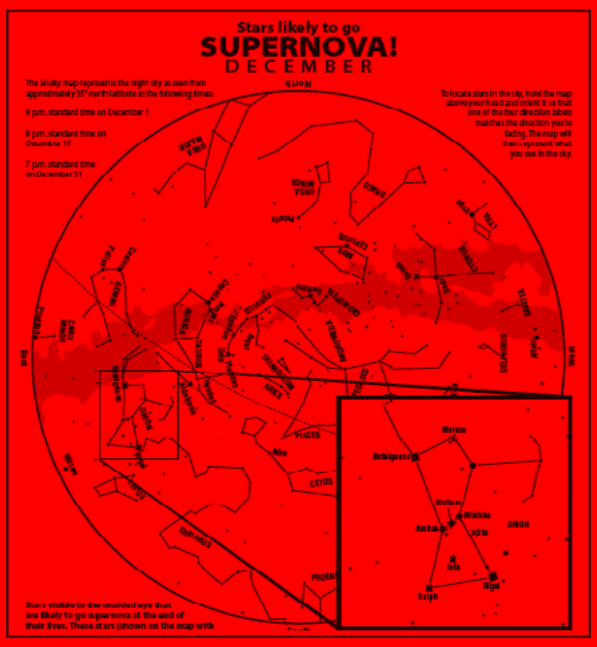
A dark sky and a telescope are your best chance to see the Crab Nebula. For access to amateur astronomers who may share views through telescopes with you, contact your local astronomy club on the NASA Night Sky Network: http://nightsky.jpl.nasa.gov/

TRY THIS!

Star Maps: Supernova!

Not all stars go supernova at the end of their lives. Only stars that are more than eight times the mass of our Sun are likely to go supernova — find out which stars in the night sky these are.

Keep watching — you might even see a supernova tonight! Astronomers estimate that supernovae happen about three times a century somewhere in our Milky Way Galaxy.



None of the stars on these maps are close enough to Earth to do any damage when they explode.

Watch the video and download the star maps here:
https://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=341

Capture your own image of the Crab Nebula!

NASA's portal to the MicroObservatory Network allows you to control a telescope right from your home computer or mobile device and tell the telescope to take your own images of the Crab Nebula and many other features of the sky.

It's easy! Start here to select your target: http://mo-www.harvard.edu/cgi-bin/OWN/Own.pl

OBSERVING WITH NASA

MicroObservatory Robotic Telescope Network, Harvard Smithsonian Center for Astrophysics

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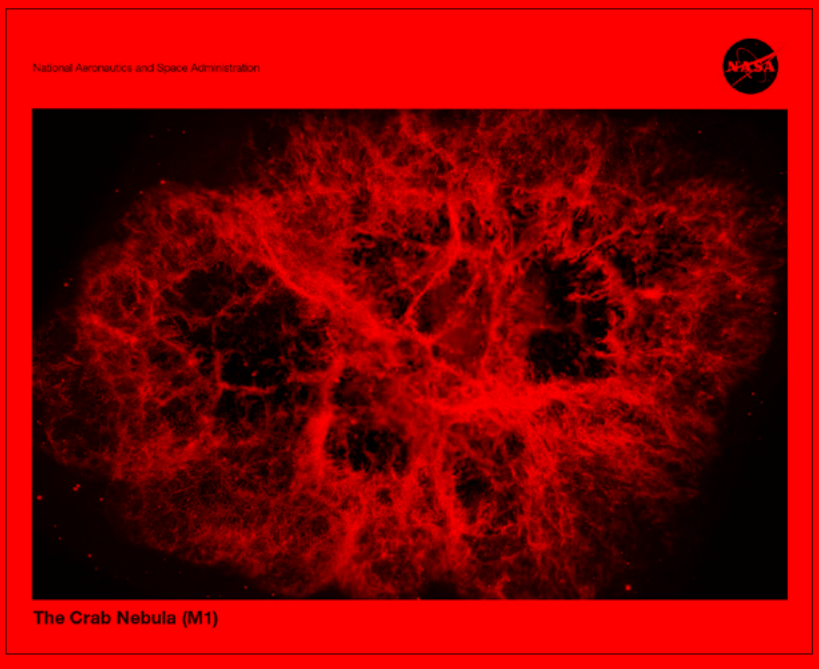
In Search of…Supernova Remnants

Use this Hubble Space Telescope lithograph from Amazing Space to learn the history of the Crab Nebula and explore the last stages of massive stars.

http://amazing-space.stsci.edu/resources/print/lithos/crabneb_litho.pdf



The Crab Nebula (M1)

For more Hubble education and public outreach activities from the Space Telescope Science Institute, visit: http://amazing-space.stsci.edu

AMAZING SPACE

http://amazing-space.stsci.edu

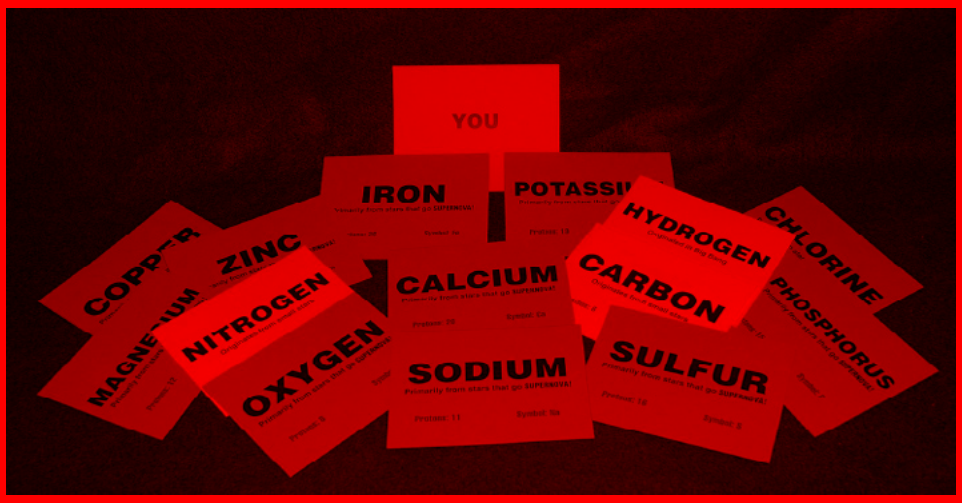
ACTIVITY: A UNIVERSE WITHOUT SUPERNOVAE

Time: 15 minutes

Age: 10 and up

With each person representing an element, a large group of people can use a set of element cards to illustrate the value of supernovae in the universe. Participants discover that almost all elements that make up the Earth and all its living things were made inside stars that go supernova. Without supernovae to disperse these elements, the universe as we know it could not exist.

http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=344

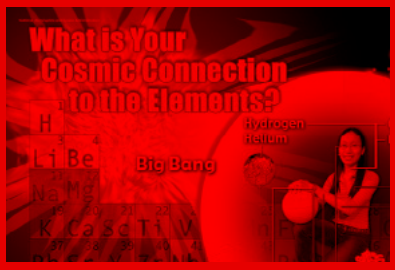


Many elements are required to make YOU. All the blue cards are elements that are made from stars that go supernova. Credit: Astronomical Society of the Pacific

Your Cosmic Connection to the Elements

For a deeper look into how the elements are generated, explore:

http://imagine.gsfc.nasa.gov/docs/teachers/elements/



Crawl of the Crab

Time: One Hour

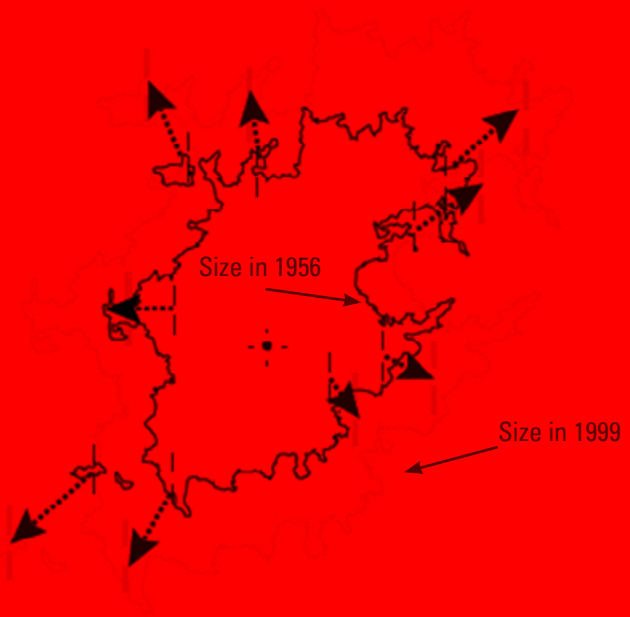
Age: 14 and up

Use this formal education activity from the Supernovae Educator Guide to illustrate how astronomers can calculate the speed of the expansion

of a supernova remnant and date the year of the explosion of the Crab Nebula. This activity can be modified for an informal setting by doing the calculations ahead of time or together on a computer.

http://xmm.sonoma.edu/edu/supernova/snguide5.pdf#page=17

Crab Nebula Expansion



For more education and public outreach activities from Fermi, XMM-Newton, Swift, and NuSTAR, see the Space Science Education and Public Outreach website from Sonoma State University:

http://epo.sonoma.edu/projects.php

Find more NASA Activities

Looking for more Earth and Space Science formal and informal education activities?

Try out NASA's digital collection of resources at NASA Wavelength: http://nasawavelength.org

http://nasawavelength.org

CONNECT TO NASA SCIENCE

How do we know that supernovae generate heavy elements?

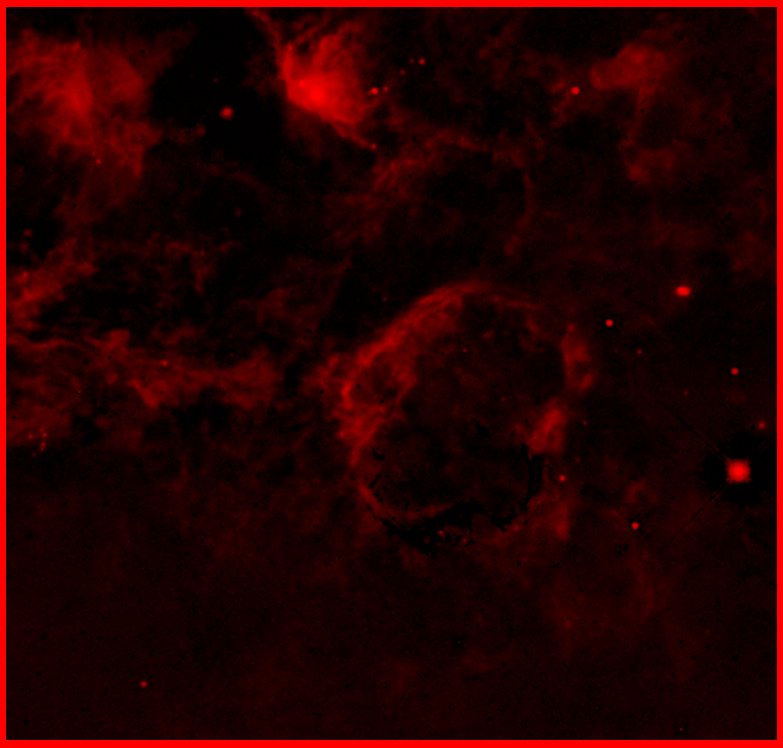
Using results from multiple space telescopes, abundant evidence has been collected that supernovae generate the elements required for rocky planets and life.

NASA's Chandra X-ray Observatory reveals silicon, sulfur, calcium, and iron in a recent supernova:

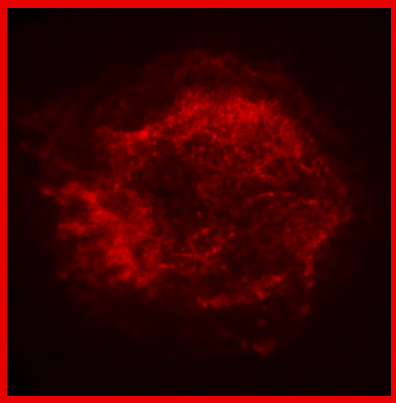
- http://chandra.harvard.edu/press/99_releases/press_122199.html
- http://chandra.harvard.edu/photo/2000/cas_a062700/

NASA's WISE Infrared space telescope exposes iron, neon, silicon, and oxygen in the remains of a supernova explosion:

http://wise.ssl.berkeley.edu/gallery_IC443.html



Jellyfish Nebula supernova remnant. Image Credit: NASA/JPL-Caltech/WISE Team



Supernova Remnant Cassiopeia A. Credit: NASA/CXC/SAO/Rutgers/J. Hughes

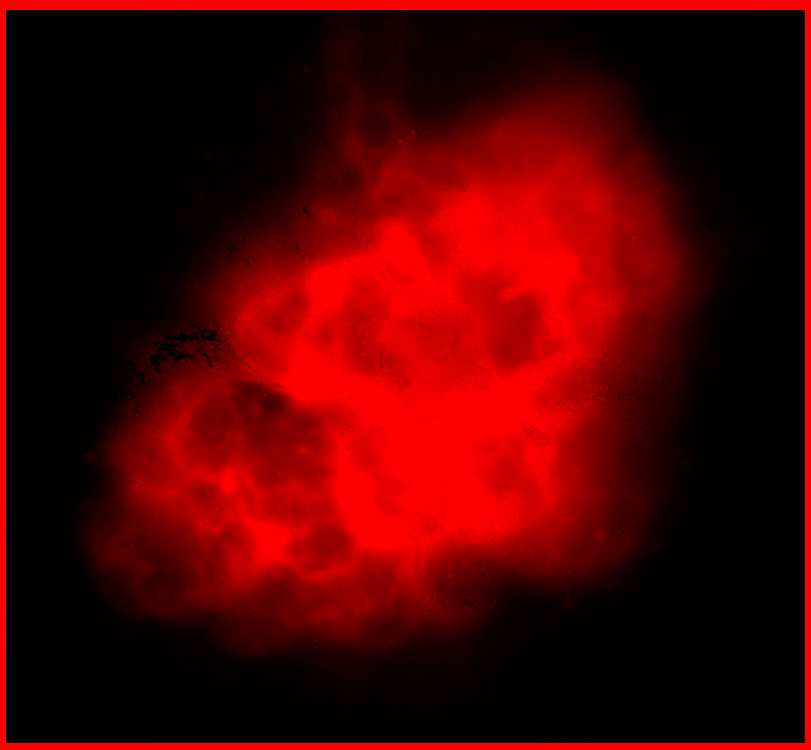
For more news from Chandra:
http://chandra.harvard.edu/press/

For more news from WISE:
http://wise.ssl.berkeley.edu/news.html

Combining X-ray, Visible, and Infrared Light Images Exposes Details of the Crab Nebula

NASA's current Great Observatories — Chandra X-ray Observatory, Hubble Space Telescope, and Spitzer Space Telescope — have observed the Crab Nebula in X-ray, visible, and infrared light, respectively. The resulting image even shows the spinning neutron star (white dot near the center), the collapsed core of the star that exploded to create the Crab Nebula.

http://www.spitzer.caltech.edu/images/2185-sig06-028-NASA-s-Great-Observatory-View-of-the-Crab-Nebula



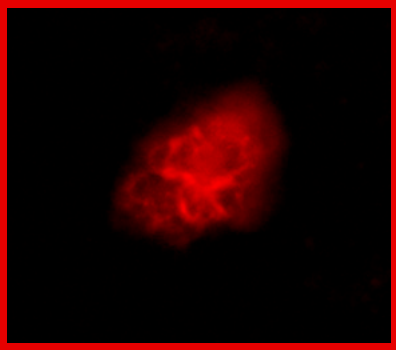
X-ray: NASA/CXC/J.Hester (ASU);
Visible: NASA/ESA/J.Hester & A.Loll (ASU);
Infrared: NASA/JPL-Caltech/R.Gehrz (Univ. Minn.)

For more news from Chandra:
http://chandra.harvard.edu/press/

For more news from Hubble:
http://hubblesite.org/newscenter/

For more news from Spitzer:
http://www.spitzer.caltech.edu/news

Supernovae: Dust Creators?



Observations of the Crab Nebula from the Herschel Space Observatory reveal that at least some supernovae are sites of dust creation.

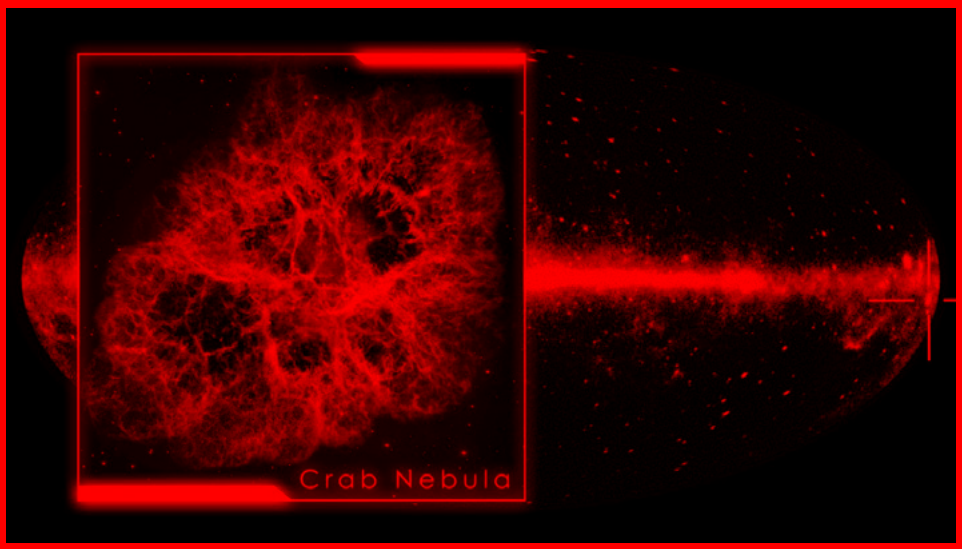
http://www.herschel.caltech.edu/index.php?SiteSection=ImageGallery&ViewImage=nhsc2012-014a

For more news from Herschel:
http://www.herschel.caltech.edu/index.php?SiteSection-News&NewsCategory=Press%20Release

Superflares from the Crab

The Fermi Gamma-Ray Space Telescope is studying the dynamic high-energy changes of the Crab Nebula. Watch the video of the surprising discovery of superflares emanating from the nebula.

http://www.nasa.gov/mission_pages/GLAST/news/crab-flare.html



For more news from Fermi:
http://www.nasa.gov/mission_pages/GLAST/news/index.html

Crab Nebula — the Movie

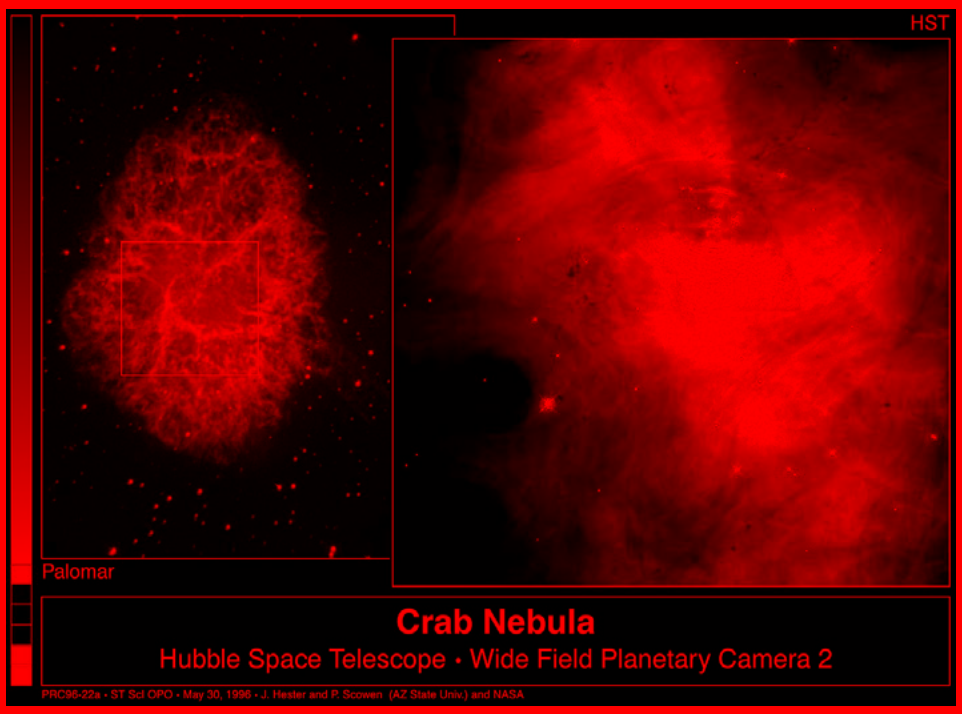
Multiple images of the Crab Nebula by the Hubble Space Telescope have revealed the wind from the central pulsar. Read all about it here:

http://hubblesite.org/newscenter/archive/releases/1996/22/text/

Watch the videos here:

http://imgsrc.hubblesite.org/hu/db/videos/hs-1996-22-b-low_mpeg.mpg

http://imgsrc.hubblesite.org/hu/db/videos/hs-1996-22-a-low_mpeg.mpg



For more news from Hubble:
http://hubblesite.org/newscenter/

To learn more about NASA Astrophysics Missions, visit:
http://science.nasa.gov/astrophysics/

ACKNOWLEDGEMENTS

The Universe Discovery Guides are a collaborative effort between members of the NASA Astrophysics education and public outreach (E/PO) community and the NASA Astrophysics Science Education and Public Outreach Forum. We also gratefully acknowledge the informal educators from the Astronomy from the Ground Up (AFGU) and the Sky Rangers communities who field-tested the guides.

Contributing NASA Astrophysics E/PO programs include: Afterschool Universe, Alien Earths, Astronomy Picture of the Day (APOD), the Chandra X-ray Observatory, the Cosmic Background Explorer (COBE), Cosmic Questions, the Euclid mission, Exoplanet Exploration, the Fermi Gamma-ray Space Telescope, the Galaxy Evolution Explorer (GALEX), the Herschel Space Observatory, the High Energy Astrophysics Science Archive Research Center (HEASARC), the Hubble Space Telescope, Imagine the Universe, the Infrared Processing and Analysis Center (IPAC), the James Webb Space Telescope, the Kepler Mission, the Milky Way Project, the Night Sky Network (NSN), the Nuclear Spectroscopic Telescope Array (Nu-STAR), Observing with NASA (OwN), Other Worlds, the Planck mission, PlanetQuest, Planet Hunters, the Spitzer Space Telescope, StarChild, the Stratospheric Observatory for Infrared Astronomy (SOFIA), the Swift mission, the Two Micron All-Sky Survey (2MASS), the Wide-Field Infrared Survey Explorer (WISE), the Wilkinson Microwave Anisotropy Probe (WMAP), the X-ray Multi-Mirror Mission (XMM-Newton), and Zooniverse.

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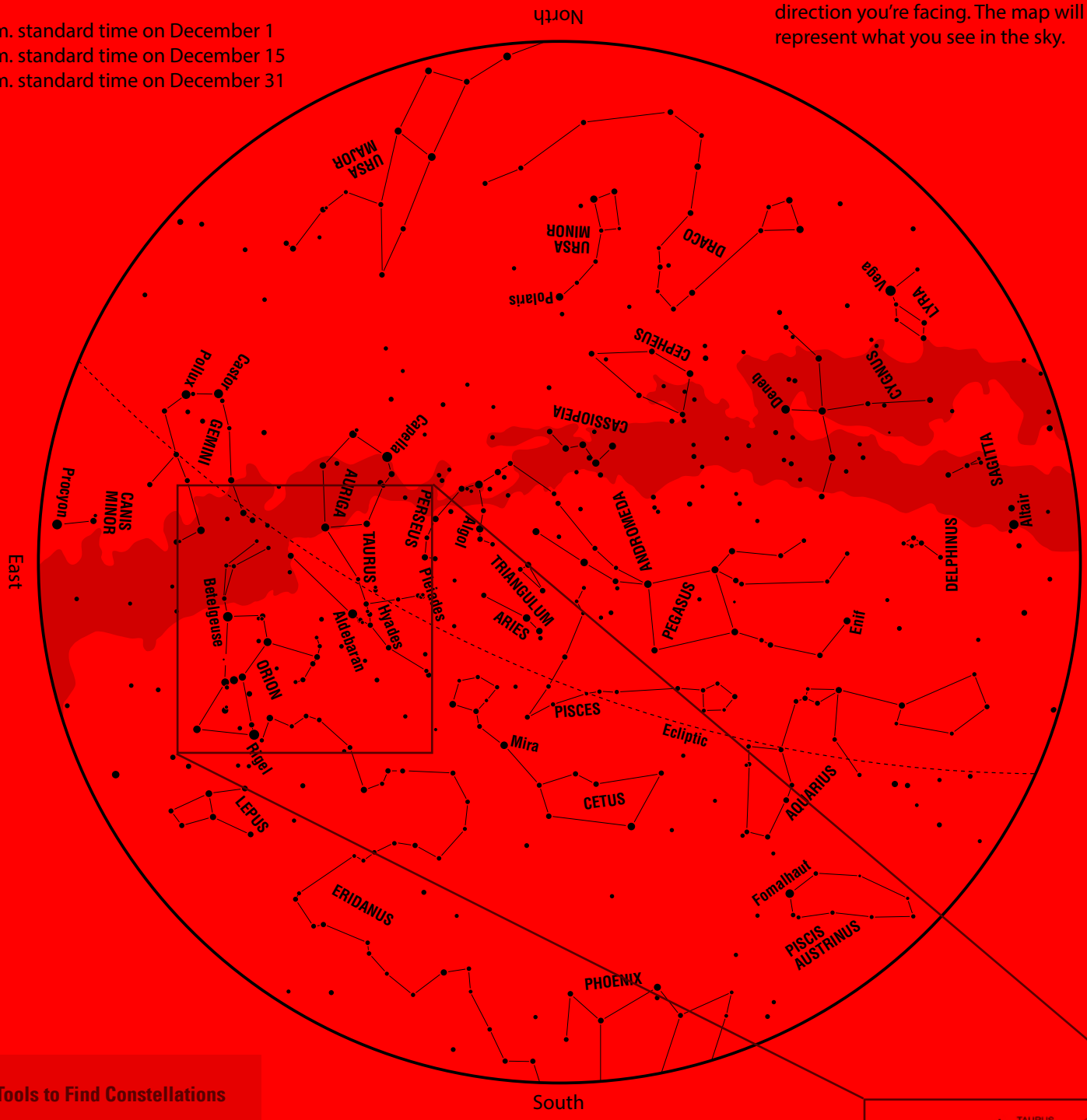
APPENDIX: DECEMBER STAR MAP

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. standard time on December 1
8 p.m. standard time on December 15
7 p.m. standard time on December 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Tools to Find Constellations

For mobile device users:
Search your app store for "planetarium" or "sky map" to find free or low-cost apps. These help you more easily locate constellations.

View a video on how to read a star map.

December Sky Feature: Crab Nebula

Jump to Sky Feature to find out about the Crab Nebula